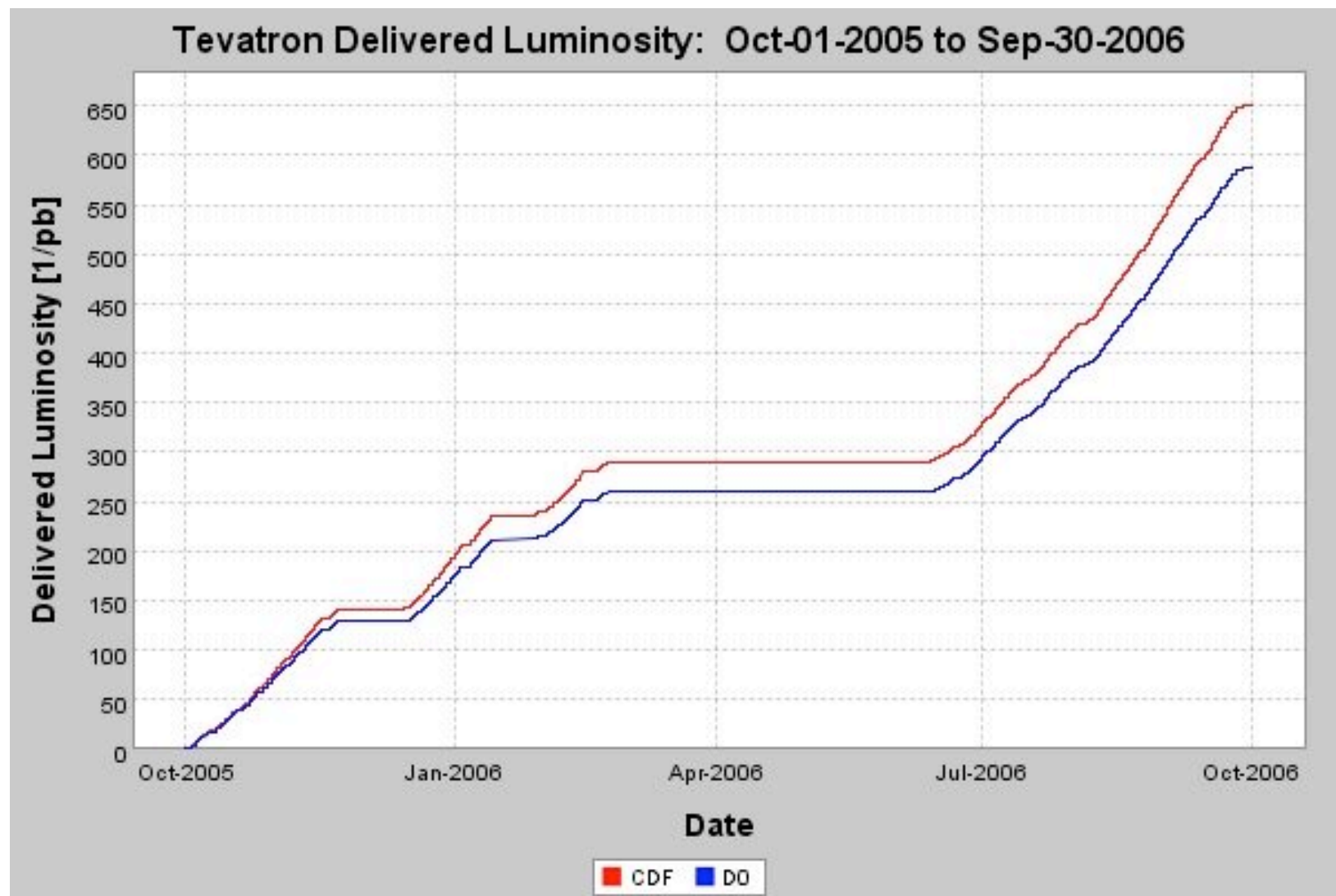


Accelerator Operations Summary

R. Dixon

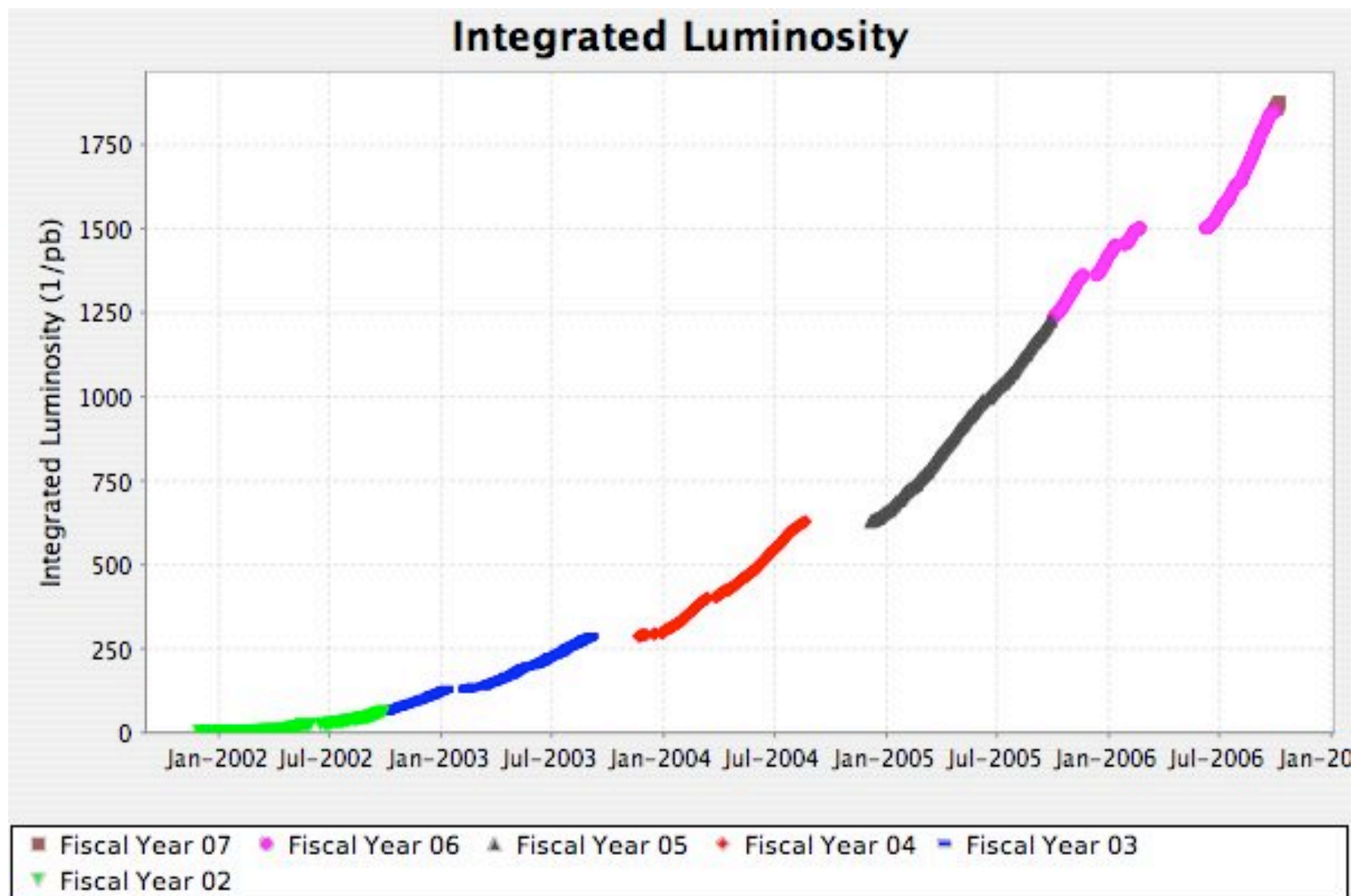


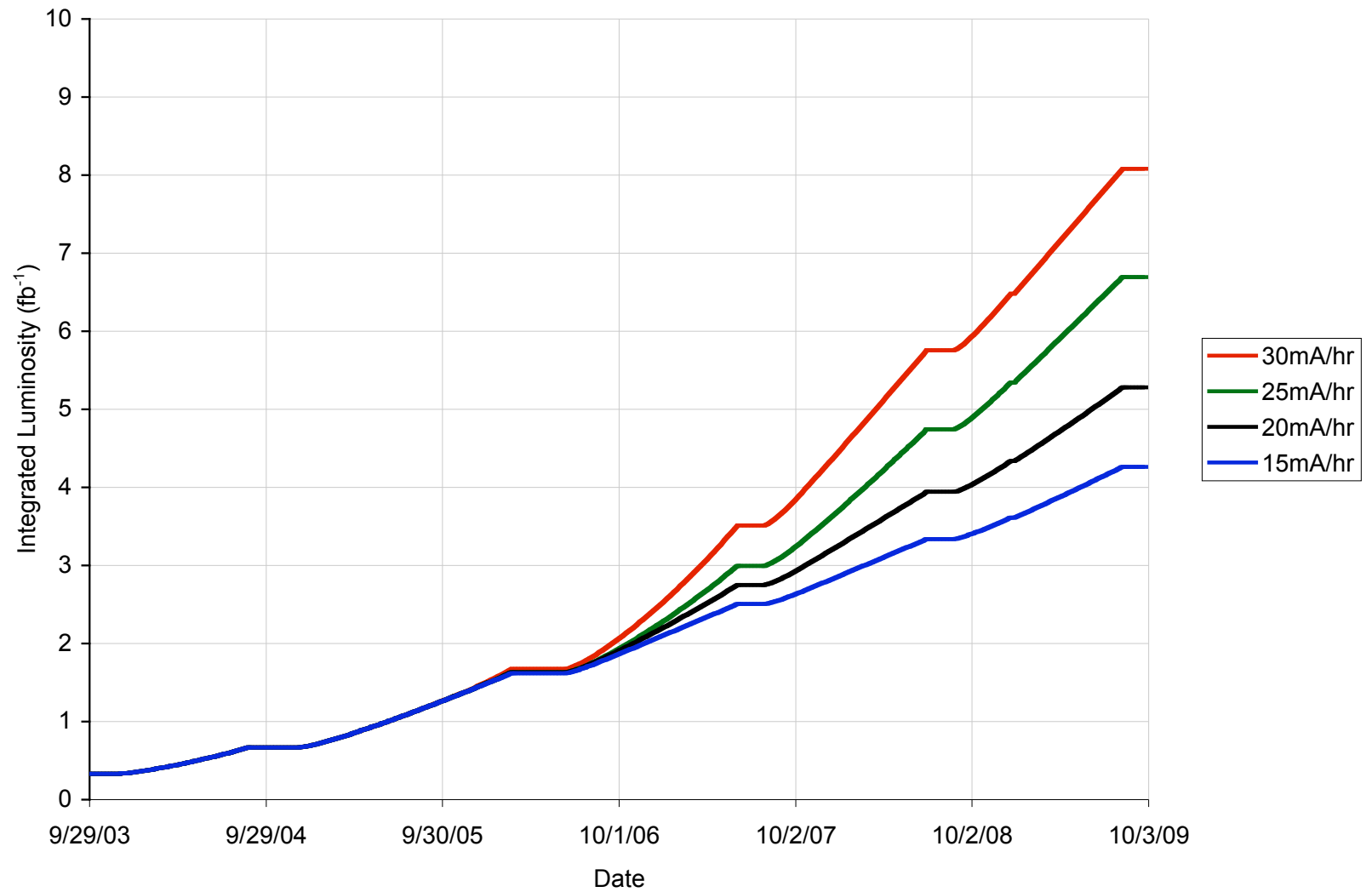
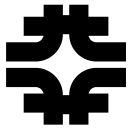
FY06 Integrated Luminosity





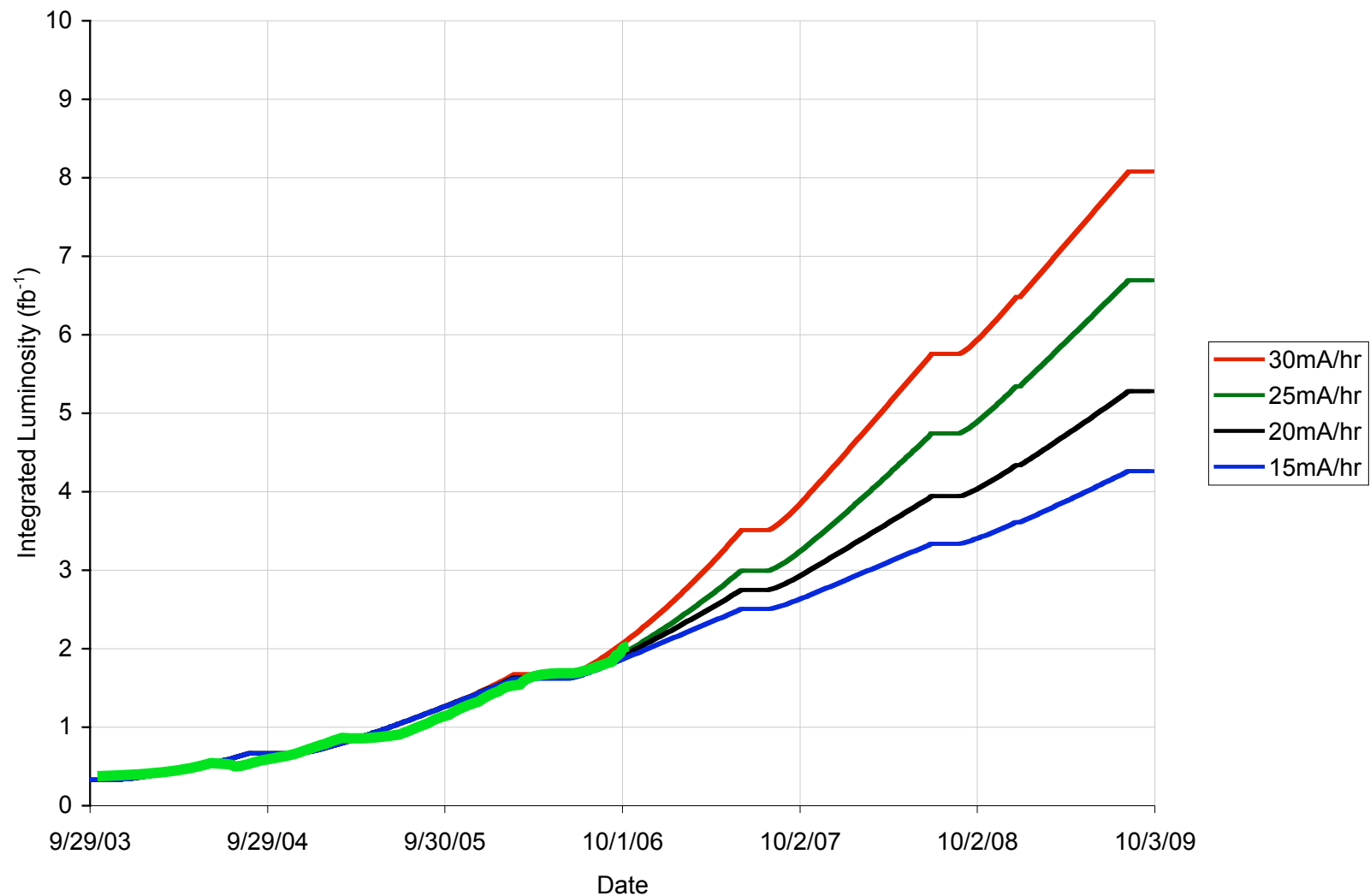
Total Integrated Luminosity for Run II





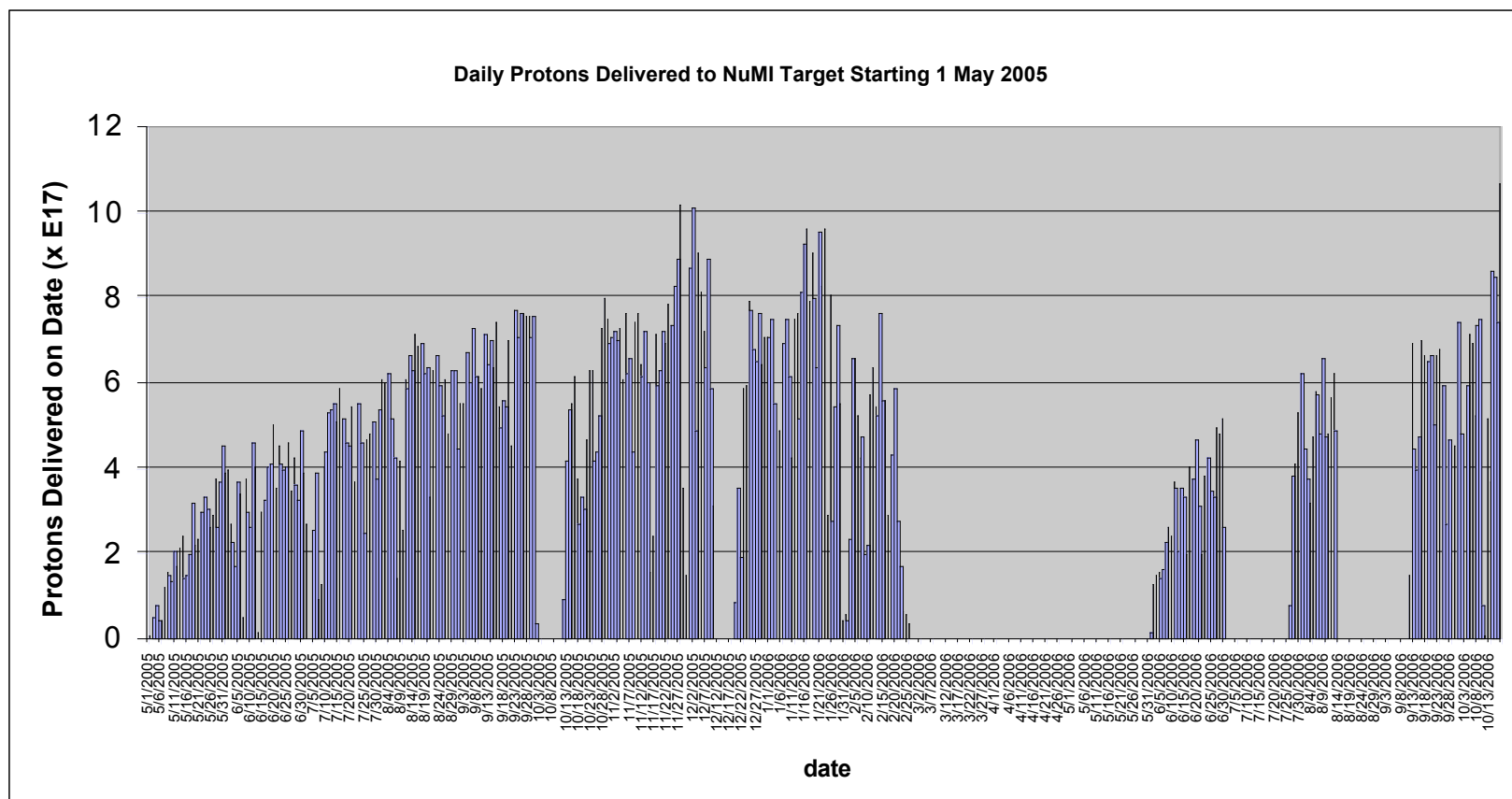


Current Luminosity vs Projections





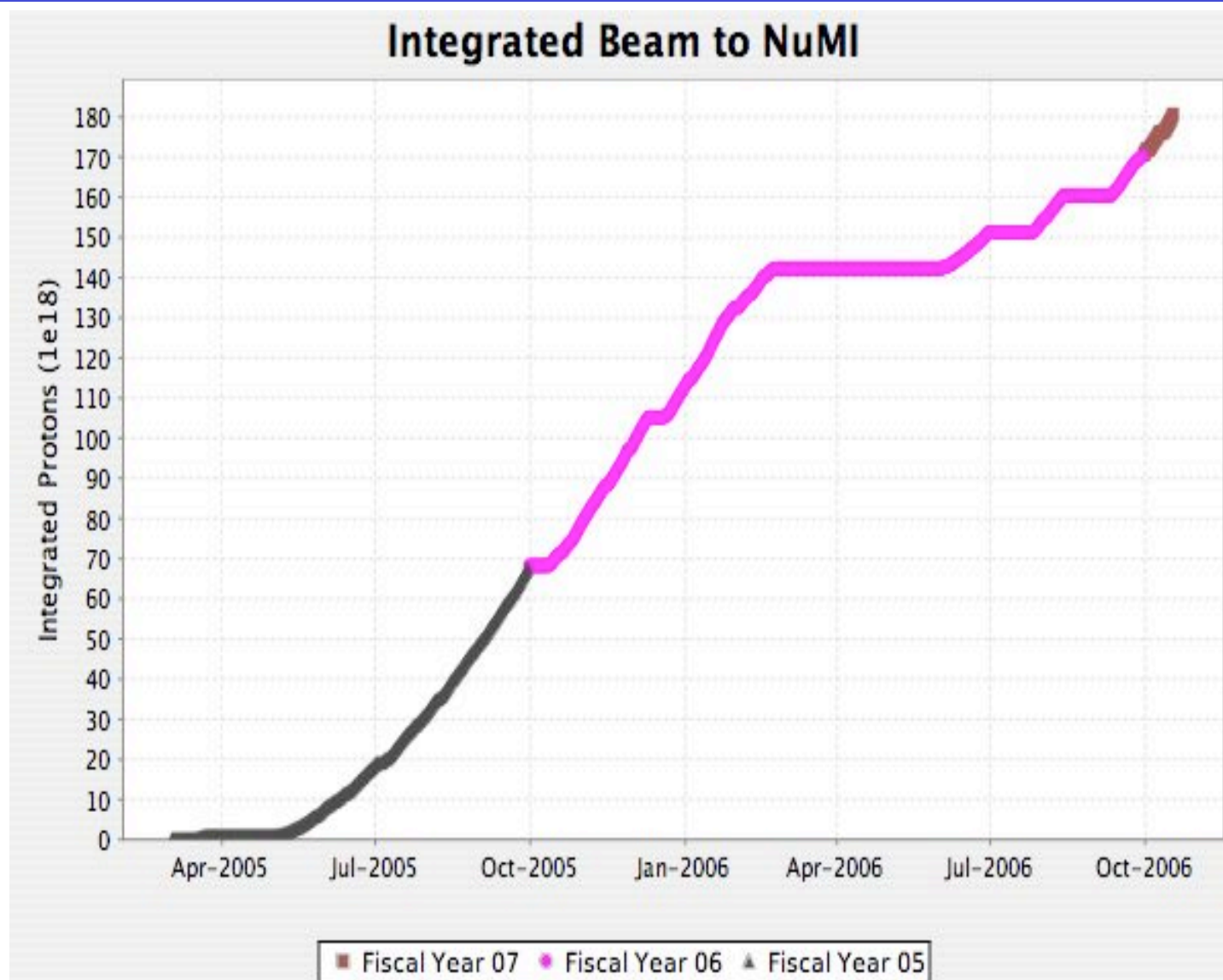
NuMI Daily Protons on Target Total 1.781E20



1.069E18 Protons delivered Oct 17' 06
New NuMI Record

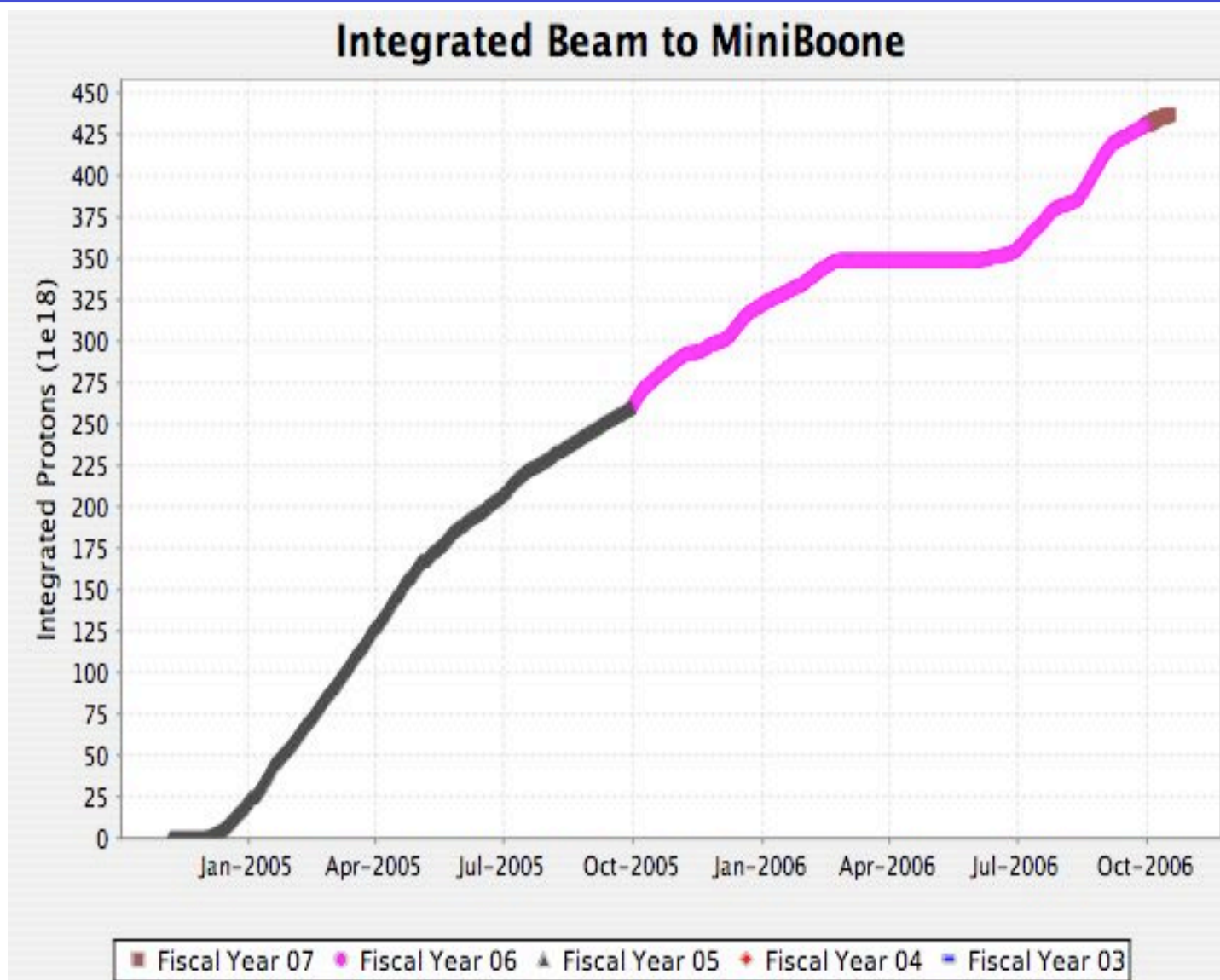


Total Protons to NuMI



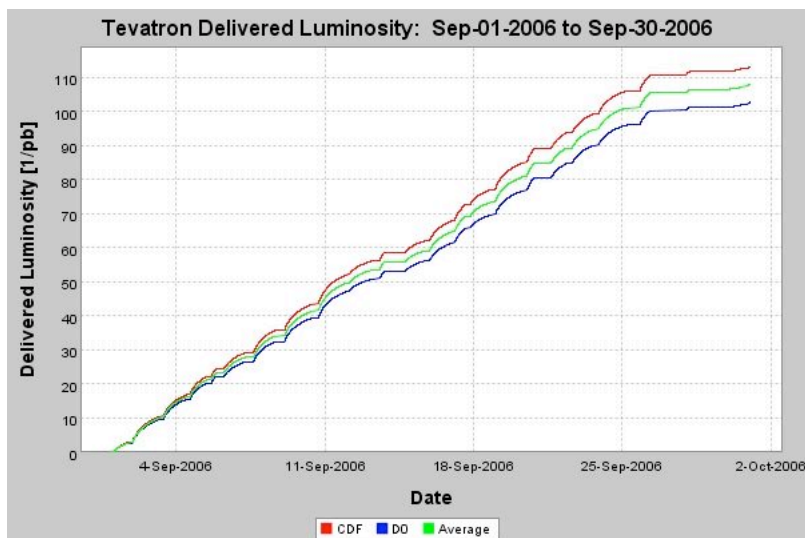
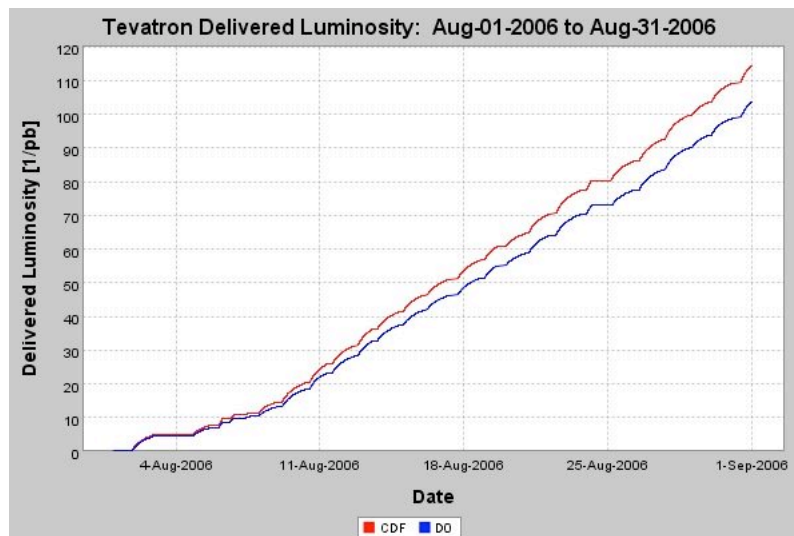
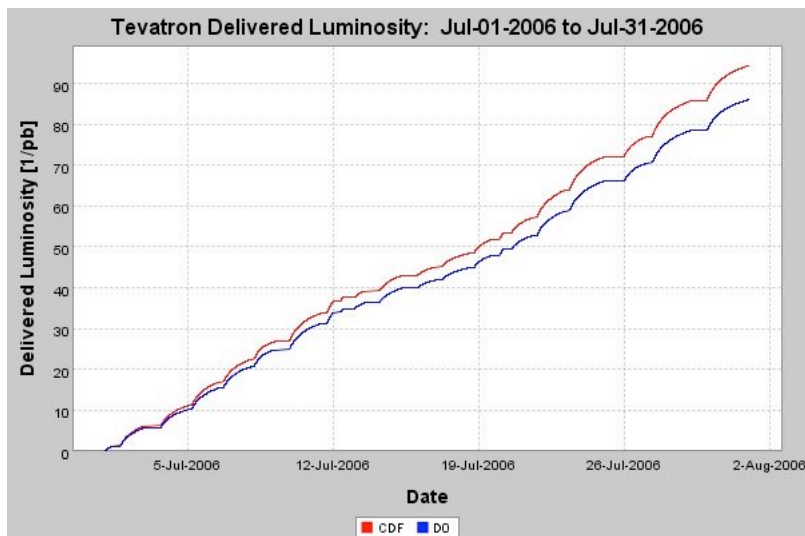


Total Protons to MiniBooNE

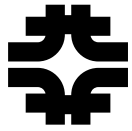




Running Since Spring Shutdown



- Record Peak Luminosity $1.8\text{E}32 \rightarrow 2.38\text{E}32$
- $> 30 \text{ pb}^{-1}/\text{week}$
- Much improved Tevatron Reliability



Major Proton Source Shutdown Projects

- Linac

- Used shutdown to make characterization measurements needed for upcoming LLRF project
 - Will improve linac energy stability and reduce injection loss

- Booster



- New injection bump (ORBUMP) scheme installed and 400 MeV line reconfigured
 - Will allow higher rep rate
 - Improves injection orbit matching and reduces losses

- RF cavity drift tube cooling completed
 - Will allow higher rep. rate



- One of the two extraction regions removed from Booster and relocated to the MI-8 transfer line
 - Reduces losses during acceleration cycle

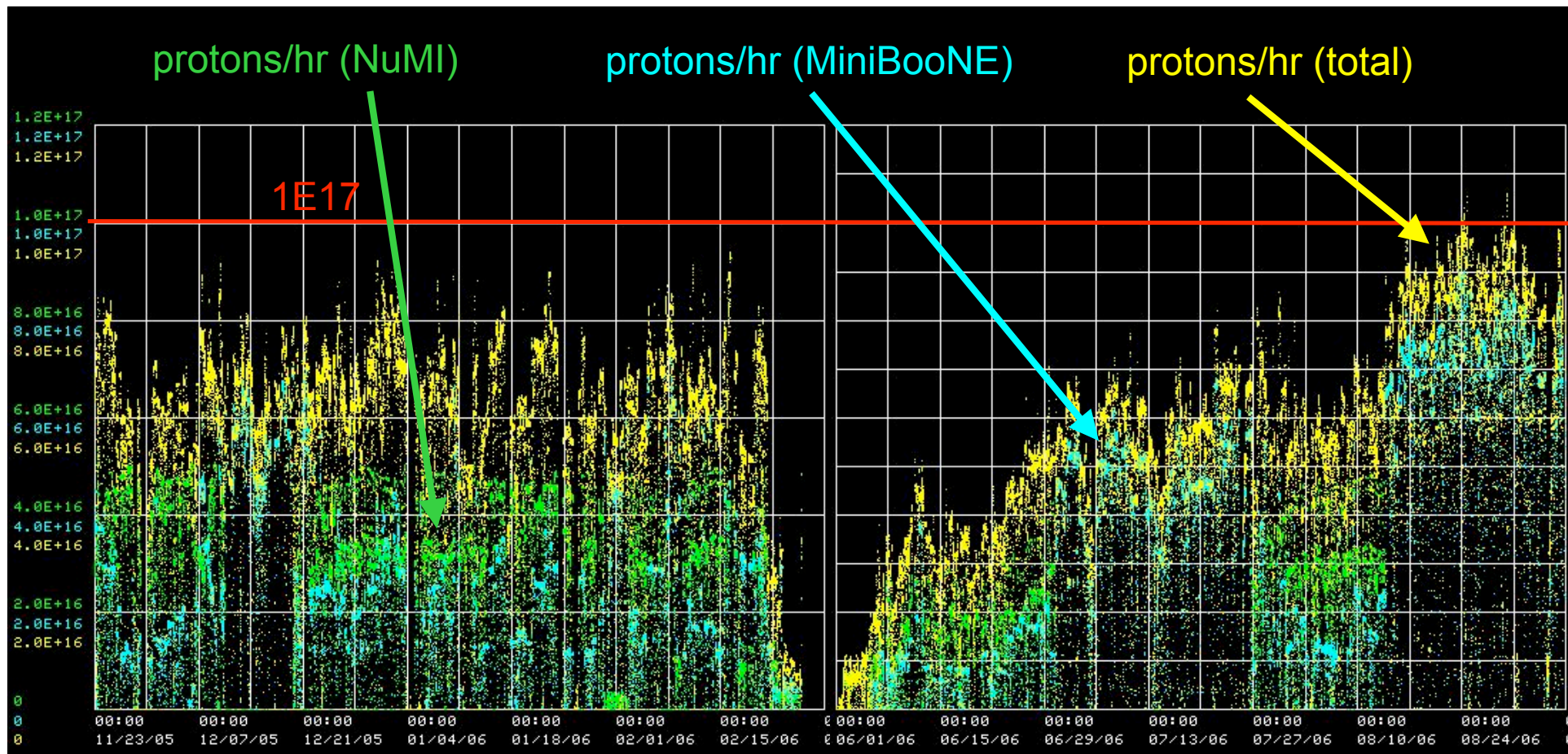
- New 13.8 kV transformers and switch gear installed for Booster RF system
 - Improved reliability at high rep. rate

- 400 MeV line LVPS replacement
 - Better reliability and stability of Booster injection

- Sump water rerouting
 - preventive maintenance for Tritium issue

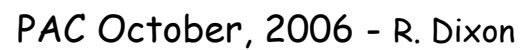


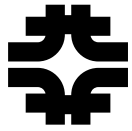
Hourly Rates



Before Shutdown

After Shutdown





Effects of Shutdown Work

- Better Injection matching
 - Beam motion reduced from 1 cm to ~2mm
- Record efficiency -> Record performance
 - Hourly rates
 - 9E16 pph MiniBooNE
 - 1E17 pph total
 - Weekly totals
 - 1.08E19 to MiniBooNE
 - 1.2E19 total
- Note: nothing that was done in this shutdown was expected to significantly increase beam to NuMI. That will come from
 - Increased up time
 - Reduced average MI cycle time
 - Slip stacking (fully operational after next shutdown)



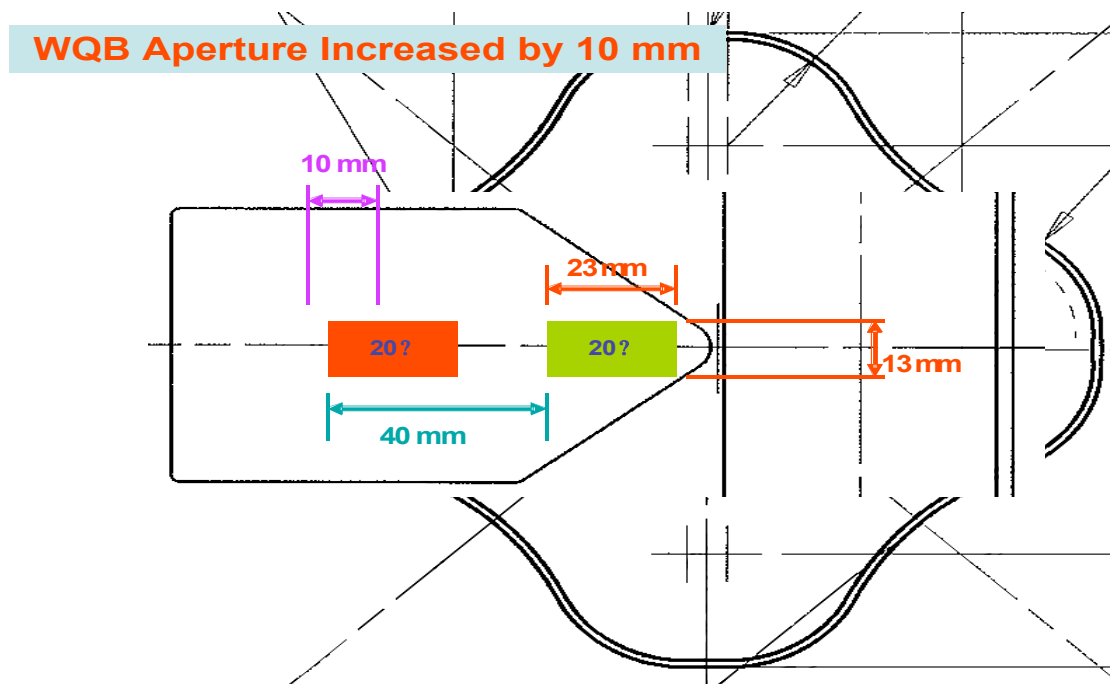
Main Injector Shutdown Work

One the 7 Installed large aperture Quads (Q222)





Aperture Increase

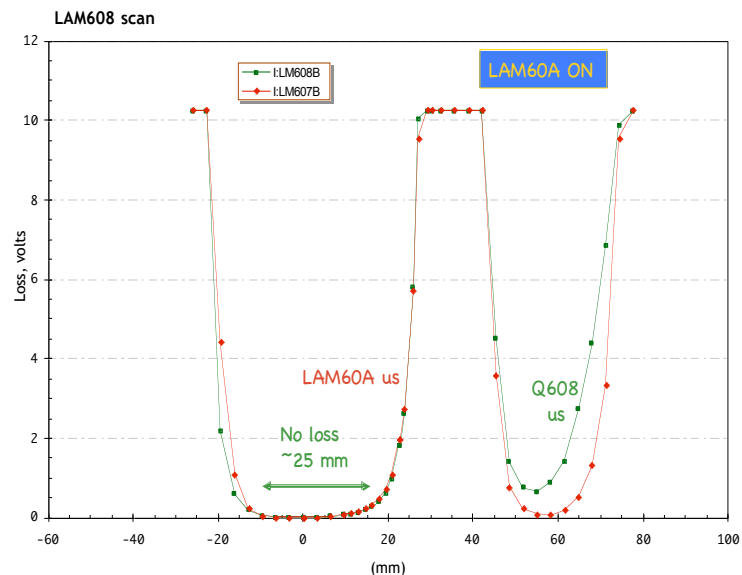




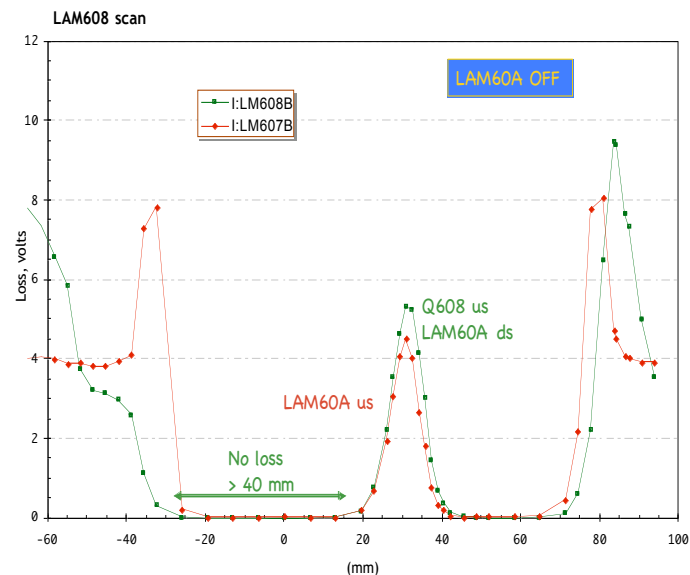
Main Injector Aperture Improvement

Aperture scans at one of the WQB Locations

MI608 aperture scan, before shut-down



MI608 location aperture scan, now



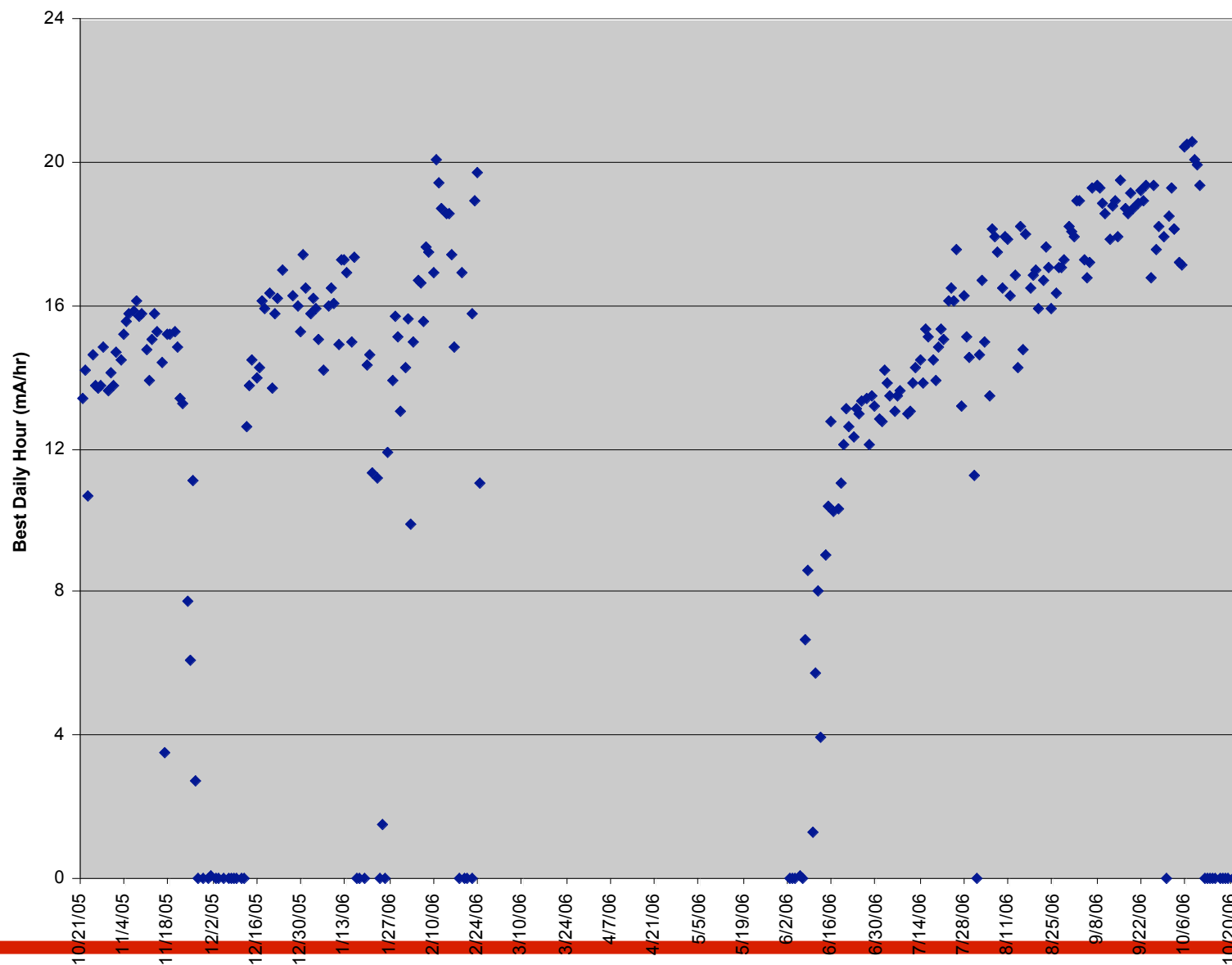


Antiproton Source Progress Since December

- Winter TeV magnet failures allowed
 - Debuncher Ring orbit, aperture and lattice
 - AP2 Beam Line orbit, aperture and lattice
 - Accumulator Ring aperture
 - Accumulator stochastic momentum cooling setup changes
- Shutdown work
 - Removed Accumulator and Debuncher aperture restrictions
 - Added motorized stand in Debuncher which allows element to be centered about orbit
 - Replaced coax with optic fiber to increase Accumulator core momentum cooling system bandwidth
- Since Shutdown
 - Accumulator Stacktail Cooling system setup changes which have increased the bandwidth slightly
 - Further Accumulator stochastic momentum cooling setup changes
 - Installation of new style production target
 - Installation of new Lithium Lens capable of higher gradient



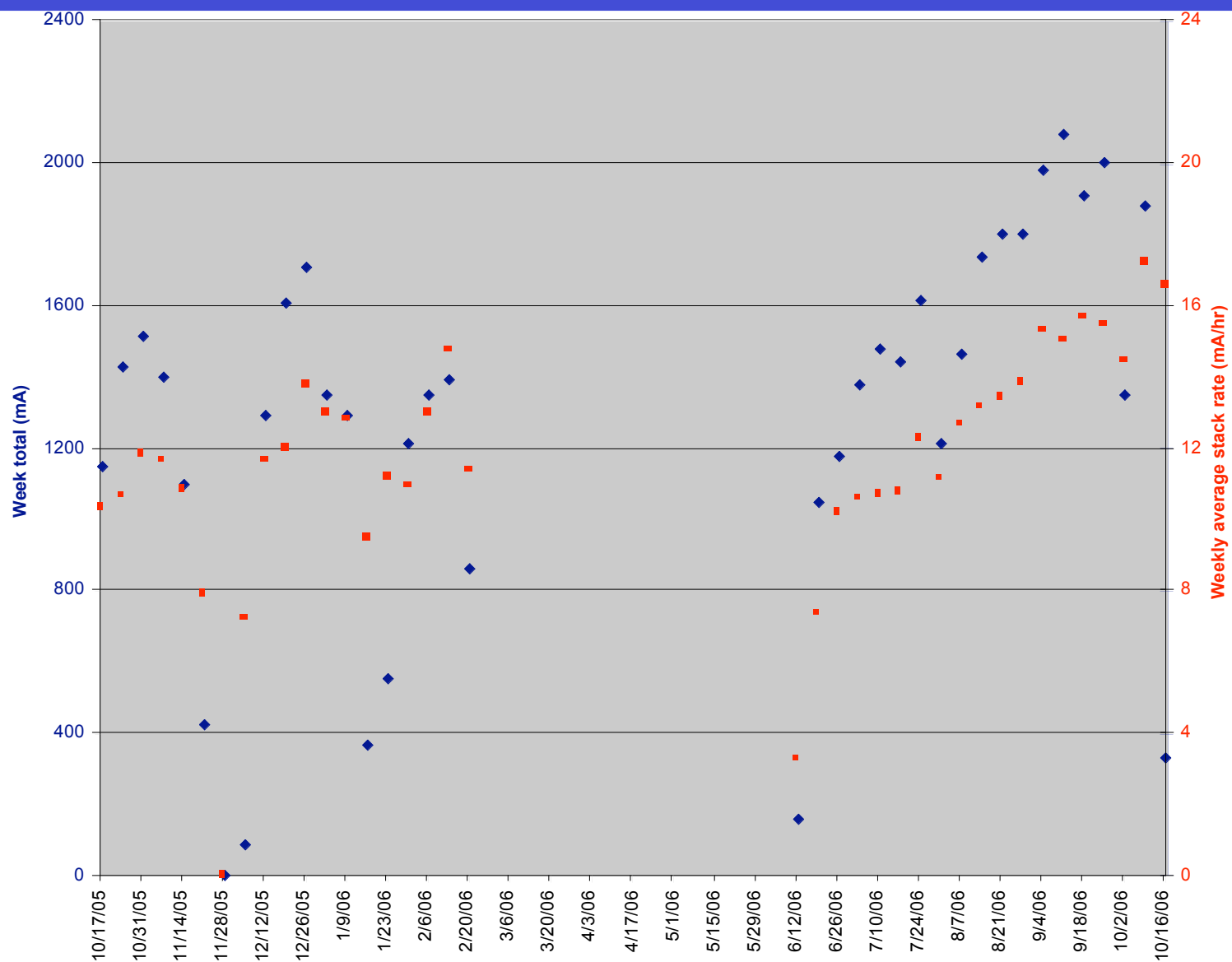
Best Hour of Stacking Each Day



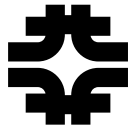
PAC October, 2006 - R. Dixon



Antiproton Source Weekly Numbers



PAC October, 2006 - R. Dixon



2006 Tevatron Shutdown Tasks

- Fixed known cold leaks in E2, A3, B4; replace failed dipole in F4
- Replaced all ≈ 1200 LHe Kautzky valves
- Completed reshimming on remaining 228 dipoles
 - Needed 3 shutdowns to do! Cryostat sagging within steel yoke - causing coupling
- Unrolled quads in A3 (~ 10 mrad) + ≈ 60 magnets with smaller rolls
 - Mistakenly "unrolled" D1 quad the wrong way
- Installed 2 new separators (B48, A17), replaced 3 separators (A49)
 - Increase separation between the protons and pbars \Rightarrow reduce beam-beam effects
- Repaired and reinstalled TEL-1 (*damaged in quench just before shutdown*)
- Installed TEL-2 (2nd electron lens) @ A1
 - Spare for TEL-1, beam-beam compensation
 - Successfully demonstrated abort gap cleaning and tune-shifting of protons in HEP
- Pulled cables for new sextupole power supplies (power supplies ready in fall)
- *Many smaller tasks, new instrumentation, lots of maintenance...*



Tevatron-centric View of Post-Shutdown Operation

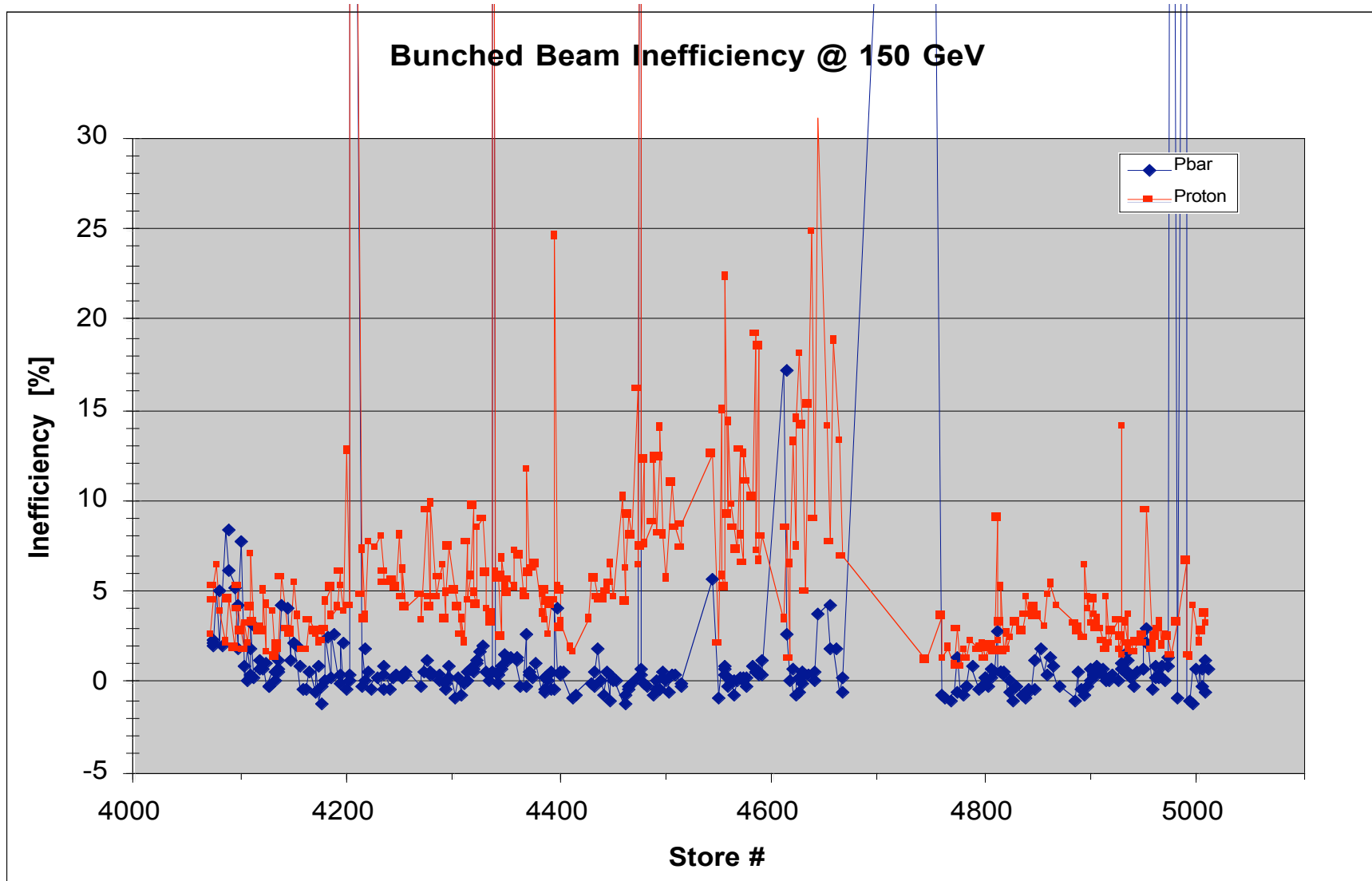
- Notable achievements since the long shutdown ended
 - Delivered lumi / week = 33.3 pb^{-1}
 - Delivered lumi from Aug 22-Sep 18 $\approx 119 \text{ pb}^{-1}$
 - Peak luminosity = $238 \cdot 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$
 - Record # pbars at start HEP $\approx 2907 \cdot 10^9$

Comparison between pre- and post-shutdown record stores			
Store	Initial Lumi* <small>$[10^{30} \text{ cm}^{-2} \text{ s}^{-1}]$</small>	# protons <small>$[10^9]$</small>	# pbars <small>$[10^9]$</small>
4581	180	8480	2340
4964	238	9300	2870
_(4581_4964)	+32%	+9.5%	+22.5%

* Includes +6% increase for D0 lumi scale correction

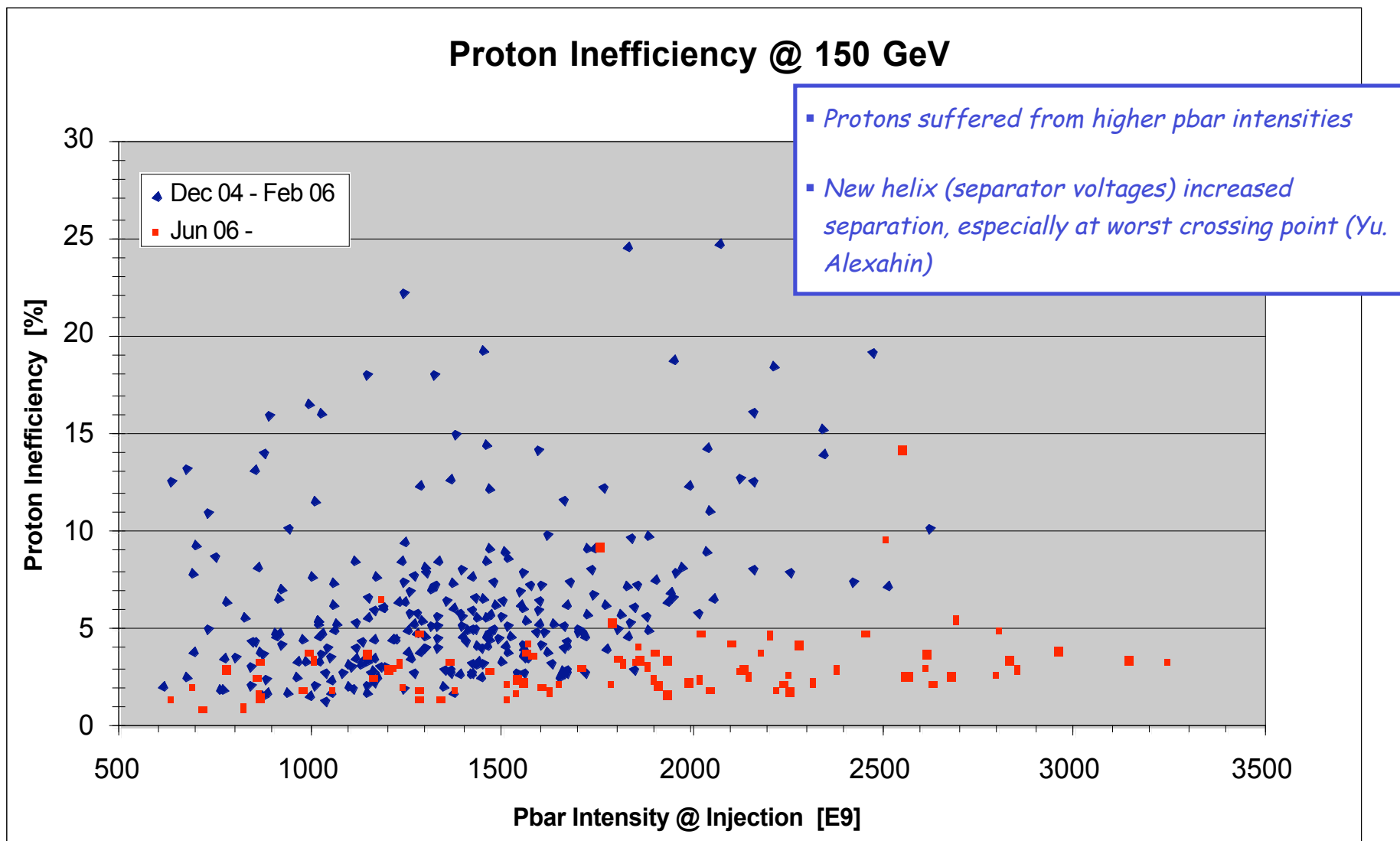


Reduced Tevatron Beam Loss @ 150 GeV





Reduced Beam-Beam Effects @ 150 GeV





Tevatron Luminosity Lifetimes

- Long-range beam-beam effects degrade luminosity lifetime + integral
 - Nearest parasitic crossings (≈ 59 m from IPs) especially bad
- During shutdown, additional separators installed to increase separation
 - More separation \Rightarrow reduced beam-beam effects

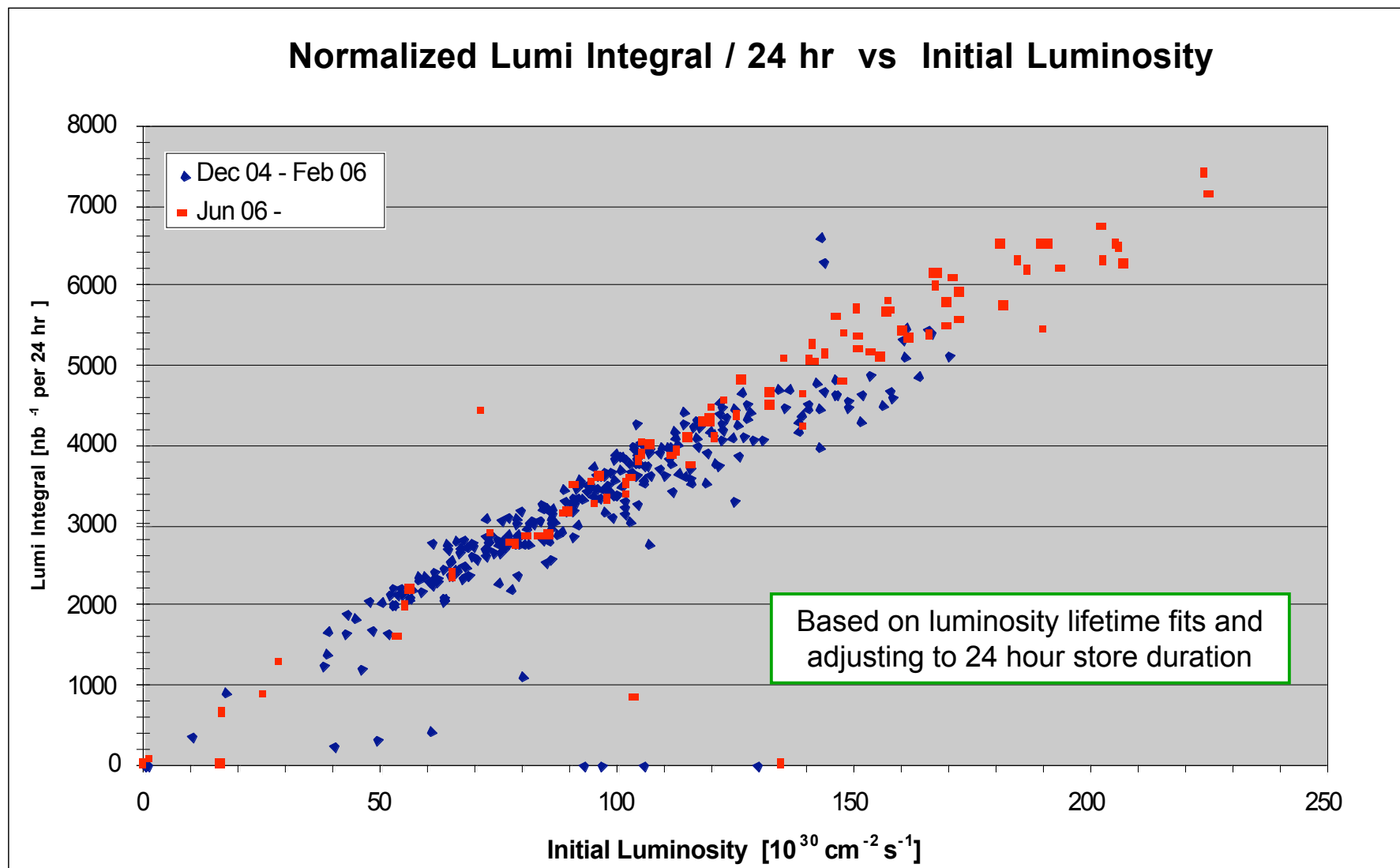
Beam separation near IPs (in σ 's)

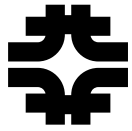
	B0 US	B0 DS	D0 US	D0 DS
Before	5.4	5.6	5.0	5.2
After	6.4	5.8	6.2	5.6

- $\sim 20\%$ increase @ upstream IP
 - Not as much @ downstream IP
- Luminosity lifetime improved $\sim 20\%$ compared to pre-shutdown running
 - Increased integrated luminosity per store (for given store length)



Better Lifetime \Rightarrow More Delivered Luminosity





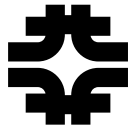
Smaller Pbar Emittances from Recycler

- New Recycler tune reduced emittance growth rate (*mid-August*)
 - ⇒ Brighter (smaller emittance) pbars delivered to Tevatron
 - ⇒ Higher instantaneous luminosity for same number of pbars...
 - ⇒ ...consequently lower luminosity lifetime (but still worth it for $\int L$)
 - ⇒ Smaller emittances also improves pbar and proton efficiencies in Tevatron
 - ⇒ Proton lifetime in collisions decreased as well



Tevatron Down Time

- A Sector Quench January 06
 - Human Error-- alarms disabled
- F4 Quench Feb 06
 - Caused by the failure of a CAMAC card
 - Beam Aborted
 - Kautzky Valve stuck in closed position
 - Resulting in Major Magnet Damage
- D3Mouse glitch
 - Mouse in Feeder Cubicle



The Chain of Events

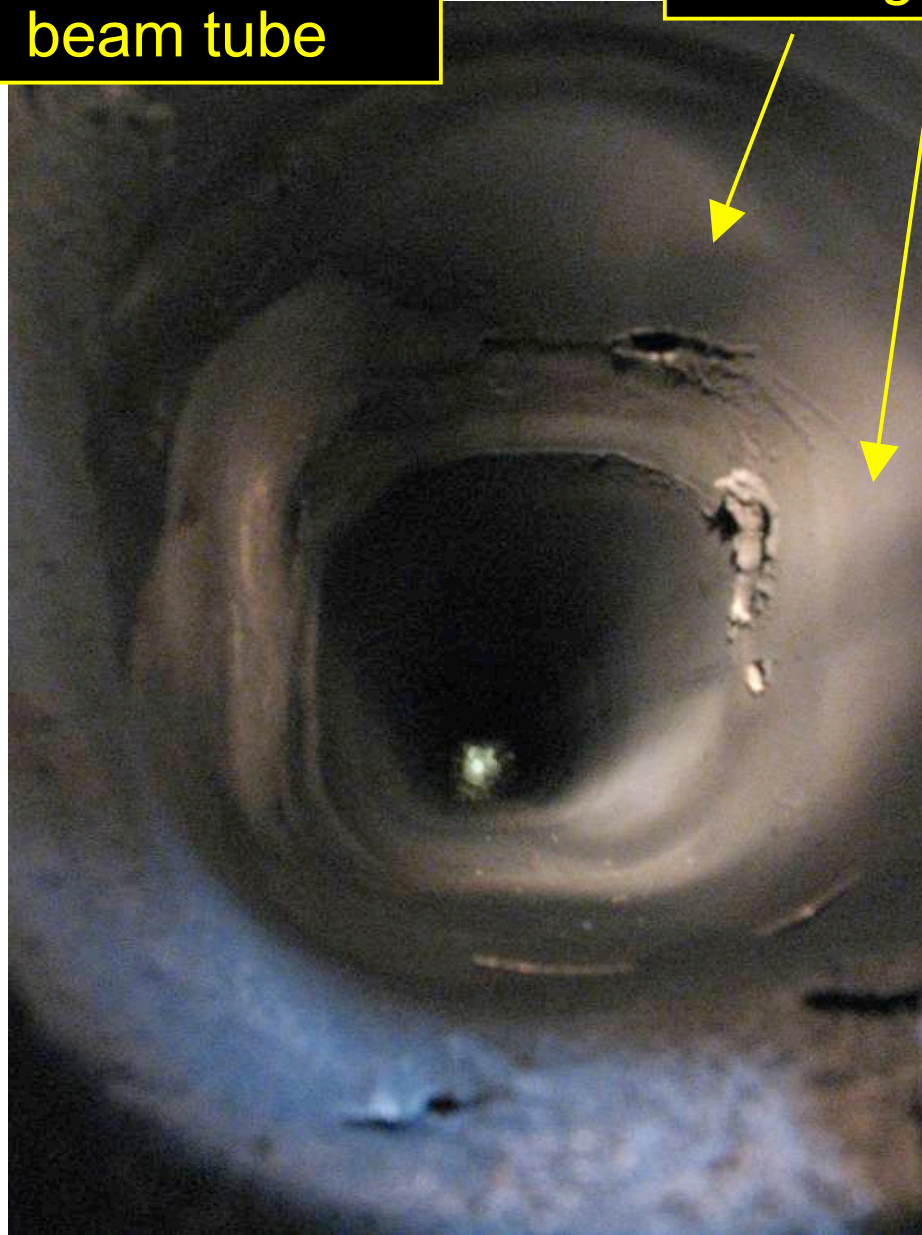
- HEP store 5008 happily spinning
 - Record # pbars injected into Tev, record # pbars reach HEP start
- Mouse seeks Feeder 46B cubicle as possible new, cozy home
 - Flashover + resulting nasty power glitch affects many systems
 - Many UPS units switched over
- Tevatron ramp begins to dump on A2 power supply trip
 - Beams aborted cleanly
- 1.2 sec into ramp dump, D3 QPM reboots (Quench Protection Monitor)
 - Why? Glitch not filtered out by UPS? UPS tested fine later...
 - As designed, QPM fired heaters, generating whole-house quench
- ≈4 sec into ramp dump, ground fault developed in D3
 - D32-5 dipole failed

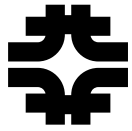
The Culprit



D32-5 dipole
beam tube

*Holes from
arcing?*





NuMI System Downtimes

- Target water leak - Mar-Apr '05
 - ~ 4 weeks. Solved with He back pressure against leak
- Horn 2 ground fault: loose support foot - Sep '05
 - ~ 3 weeks. Replaced foot
- Chiller compressor condensate collection - Dec. '05
 - ~ 2 weeks. Installed condensate recovery tank
- Horn 2 water leak at ceramic - Feb. '06
 - No downtime. Fixed during machine shutdown
- Horn 1 DI bottle resin bead contamination - June '06
 - ~ 4 weeks. Cleaned water system; installed backflow protections
- Horn 1 water leak at ceramic - Aug.'06
 - ~ 3 weeks. Replaced ceramic section.
- Target motion control - Aug.'06
 - ~ 1 week. Replaced target



NuMI Horns Experience

Horns were
put in
target hall
June 2004

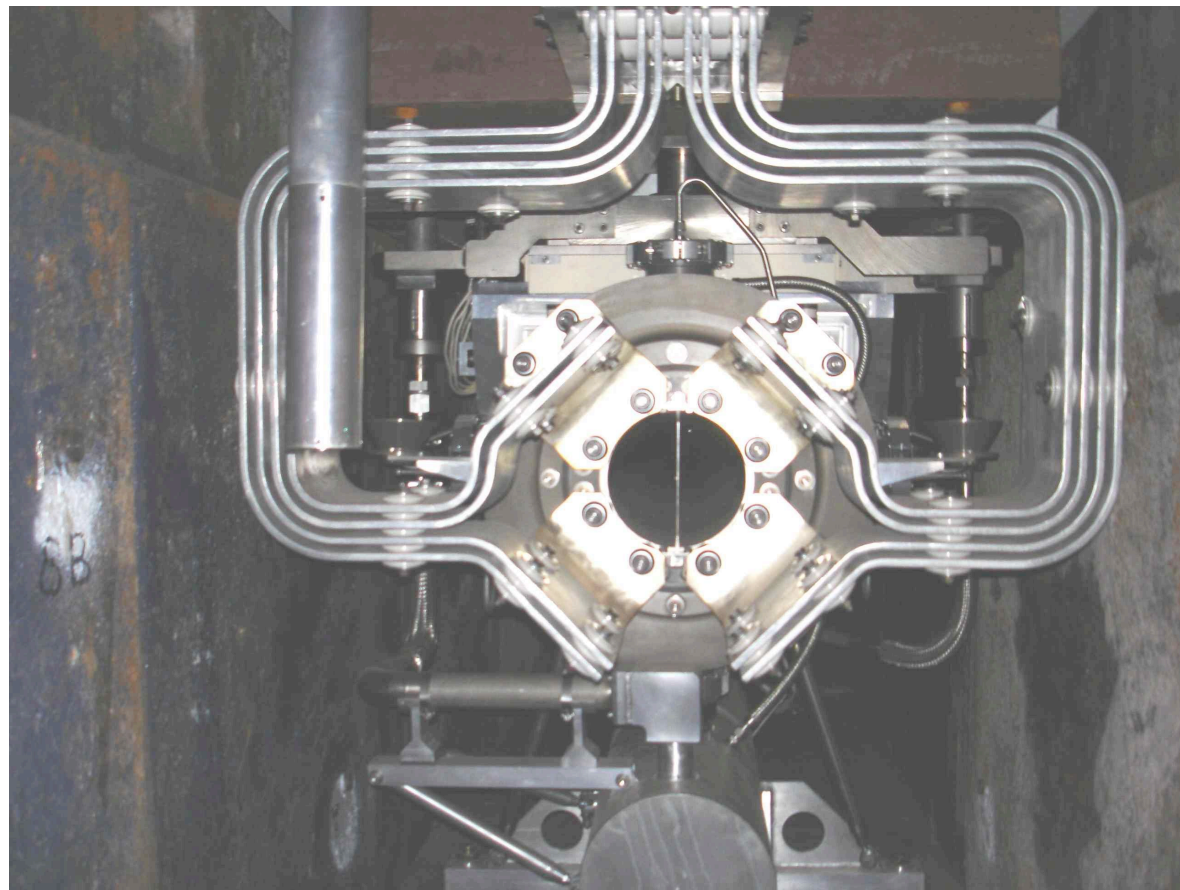
1st run with
beam
Jan. 2005

Accumulated:

9.2 Million
pulses

820 MWhr
integrated beam power

Still running with first set of horns





Two horn water system leaks

Horn 2 in February 2006, Horn 1 in August 2006

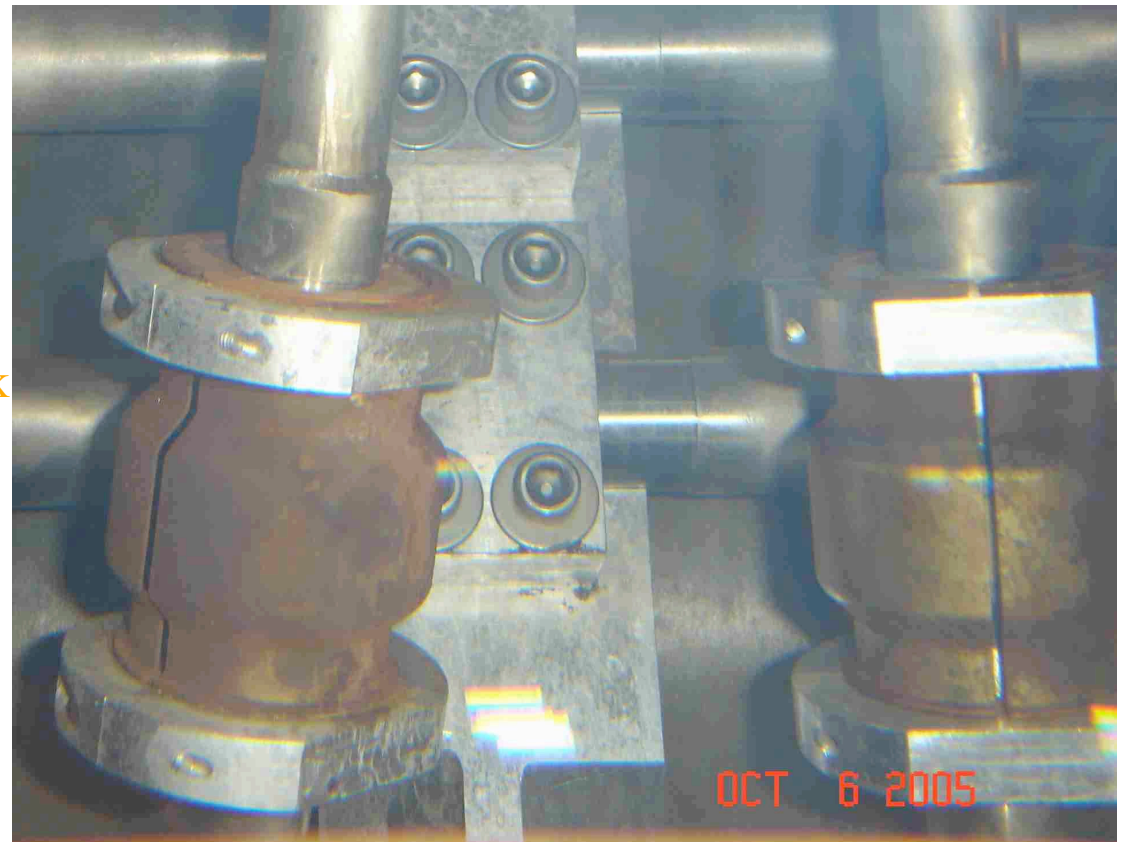
Have brazed ceramic electrical insulators on horn water lines
They are strain-relieved with invar+ceramic clam-shells

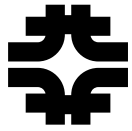
On horn 1, developed a 7gal/day
water leak on line to spray header

On horn 2, leak on suction line
drew air in, reducing amount
of water ejector pump could
remove from horn collection tank

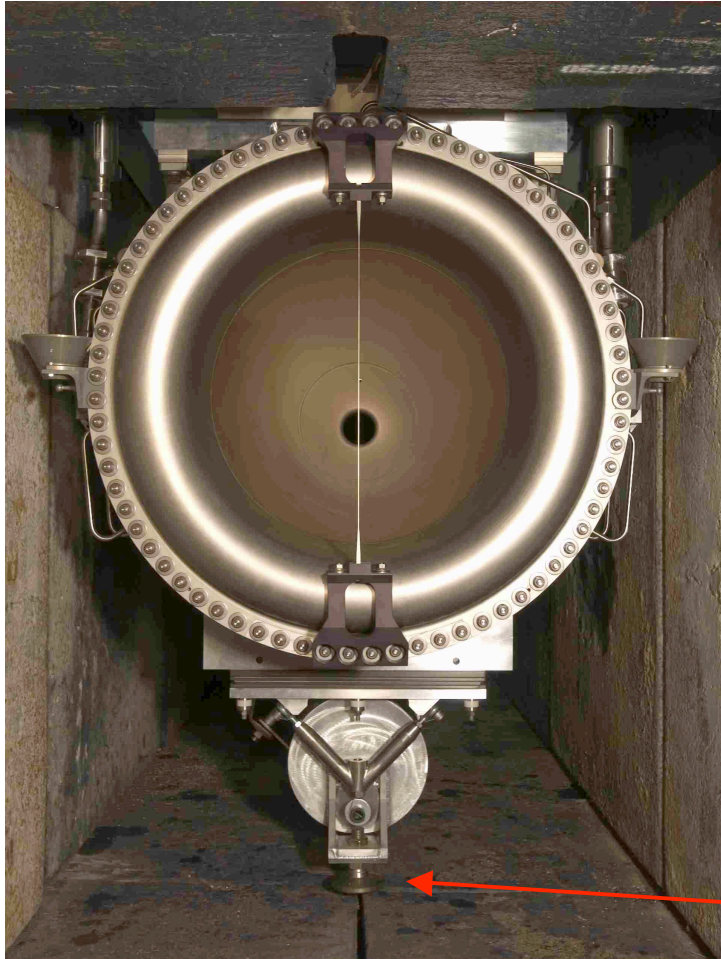
Both ceramic sections were
successfully replaced

Speculate braze corrodes...
planning to switch from brazed
to a shrink-fit ceramic/steel
connection for spare horns





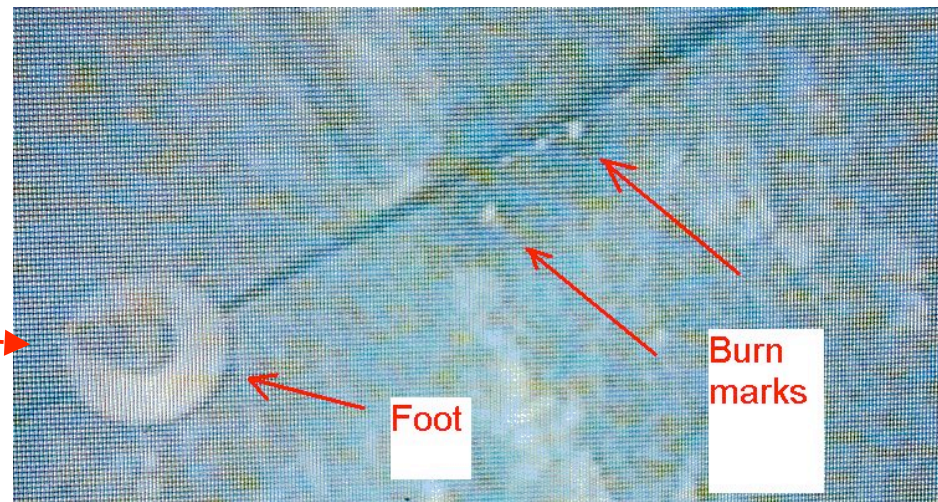
Horn 2 ground fault - - loose foot on horn



Horn 2 before beam
1.5 inch clearance foot to floor

Owl shift Thurs. Sept. 29, 2005 intermittent horn trips.
Owl shift Sat. Oct. 1, hard ground fault of 1 ohm.
*-removing stripline fingers Horn 2 + stripline block
-when Horn 2 moved to work cell ground fault cleared
-foot left behind in chase, nut had vibrated off
-scorch marks seen under foot*

Moved old foot, installed new foot





Summary

- Incredible Start up after spring shutdown
 - Good potential for increasing integrated luminosity
 - Tevatron Performing very well
 - Need a better mouse trap
 - Beam-beam interactions under control and we have a tool for the future if there are more problems
 - We must continue to improve stacking
 - We have a good handle on further improvements
 - Must continue to work on the reliability of the entire complex
 - NuMI horns and targets
 - Tevatron failures
-